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Are energy conservation policies effective without harming economic growth in the Gulf Cooperation Council countries?

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ABSTRACT

This study explores the fossil fuels electricity consumption-growth of the gross domestic product (GDP) relationship in the six Gulf Cooperation Council (GCC) countries for the period 1980–2012. The aim of this study is to examine whether energy conservation policies are appropriate for these countries to reduce their high levels of electricity consumption. The autoregressive distributed lag (ARDL) and the Toda–Yamamoto–Dolado–Lütkepohl (TYDL) methodologies were employed to investigate this relationship. The ARDL results revealed that fossil fuels electricity consumption has a long run positive effect on GDP growth in the GCC countries. However, the TYDL Granger causality revealed different causality relationships among the countries. A bi-directional causality was found between fossil fuels electricity consumption and GDP growth in Bahrain and the United Arab Emirates (UAE) while one way causality from fossil fuels electricity consumption to GDP growth was found in Oman and Qatar. On the other hand, no causality was concluded between the variables in Kuwait and Saudi Arabia. From the results, it is clear that energy conservation is not an ideal policy for the Bahrain, UAE, Oman, and Qatar because it will have a negative consequence on their output. However, this policy can be implemented in Kuwait and Saudi Arabia since it will not harm their output.

Contents

1. Introduction

Electricity consumption in the Gulf Cooperation Council (GCC) countries witnessed a remarkable increase in the last three decades. The consumption of electricity increased from 36.931 billion Kilowatt-hours in 1980 to 3711 billion Kilowatt-hours in 2010 which represents over 9% increase annually [1] and it is expected to increase a further 2.5% in the future [2]. Moreover, these countries are envisaged to be the leading countries in per capita electricity consumption. However, most of the electricity generation in these countries is produced from fossil fuels; the energy mix for each country is reviewed in Table 1. For instance, in 2011, over 98% of electricity production came from petroleum and natural gas [1]. Therefore, their rapid increase in electricity consumption had made huge environmental pressure whereby the levels of CO_2 emissions have more than doubled in the last three decades [2]. The main reason behind the increase in

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Table 1
The electricity production mix for the GCC Countries.
Source: World Development Indicators of World Bank.

Country name	The Electricity energy mix for the GCC countries	1985	1990	1995	2000	2005	2011
Bahrain	Electricity production from coal sources (% of total)	0	0	0	0	0	0
Bahrain	Electricity production from hydroelectric sources (% of total)	0	0	0	0	0	0
Bahrain	Electricity production from natural gas sources (% of total)	100	100	100	100	100	100
Bahrain	Electricity production from oil sources (% of total)	0	0	0	0	0	0
Bahrain	Electricity production from renewable sources, excluding hydroelectric (% of total)	0	0	0	0	0	0
Kuwait	Electricity production from coal sources (% of total)	0	0	0	0	0	0
Kuwait	Electricity production from hydroelectric sources (% of total)	0	0	0	0	0	0
Kuwait	Electricity production from natural gas sources (% of total)	27.216709	44.547275	53.473276	32.92083	25.078886	38.012775
Kuwait	Electricity production from oil sources (% of total)	72.783291	55.452725	46.526724	67.07917	74.921114	61.987225
Kuwait	Electricity production from renewable sources, excluding hydroelectric (% of total)	0	0	0	0	0	0
Oman	Electricity production from coal sources (% of total)	0	0	0	0	0	0
Oman	Electricity production from hydroelectric sources (% of total)	0	0	0	0	0	0
Oman	Electricity production from natural gas sources (% of total)	73.939151	81.626305	80.476923	82.833937	81.997154	82.001463
Oman	Electricity production from oil sources (% of total)	26.060849	18.373695	19.523077	17.166063	18.002846	17.998537
Oman	Electricity production from renewable sources, excluding hydroelectric (% of total)	0	0	0	0	0	0
Qatar	Electricity production from coal sources (% of total)	0	0	0	0	0	0
Qatar	Electricity production from hydroelectric sources (% of total)	0	0	0	0	0	0
Qatar	Electricity production from natural gas sources (% of total)	99.214991	100	100	100	100	100
Qatar	Electricity production from oil sources (% of total)	0.7850089	0	0	0	0	0
Qatar	Electricity production from renewable sources, excluding hydroelectric (% of total)	0	0	0	0	0	0
Saudi Arabia	Electricity production from coal sources (% of total)	0	0	0	0	0	0
Saudi Arabia	Electricity production from hydroelectric sources (% of total)	0	0	0	0	0	0
Saudi Arabia	Electricity production from natural gas sources (% of total)	57.60195	50.988325	45.312021	46.034186	56.495991	43.339851
Saudi Arabia	Electricity production from oil sources (% of total)	42.39805	22.459831	23.110807	27.681055	30.077673	26.450653
Saudi Arabia	Electricity production from renewable sources, excluding hydroelectric (% of total)	0	0	0	0	0	0
UAE	Electricity production from coal sources (% of total)	0	0	0	0	0	0
UAE	Electricity production from hydroelectric sources (% of total)	0	0	0	0	0	0
UAE	Electricity production from natural gas sources (% of total)	96.291667	96.288056	96.893764	96.908171	97.863192	98.301341
UAE	Electricity production from oil sources (% of total)	3.7083333	3.7119438	3.1062365	3.0918286	2.1368085	1.6986594
UAE	Electricity production from renewable sources, excluding hydroelectric (% of total)	0	0	0	0	0	0

electricity consumption is the increasing demand for electricity from the growing population in the 6 GCC countries which are Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and UAE. The population of the GCC's six member states reached an estimated 49 million in 2013, a sharp increase from 33.2 million in 2004, and is predicted to hit 53 million in 2014. Thus, more than 47% of the electricity consumption is dedicated for residential use. Furthermore, since these countries neither industrial nor have a service based economies, less than 11% of the electricity use goes to these sectors which are low compared to the other major electricity consuming countries. Therefore, the effect of electricity consumption may or may not have an impact on the GCC's output.

The electricity-GDP growth relationship has been explored by many scholars via utilizing different methodologies. These scholars reached diverse conclusions. From the literature (see Table 2), the long run relationship between the electricity consumption and GDP growth was confirmed in 91% of the studies. However, the causal relationship between the two variables varied across the studies. The bi-directional causality between electricity consumption and GDP growth was found in a number of studies, this causal relationship represents the feedback hypothesis. The feedback hypothesis indicates that the energy consumption and GDP are jointly determined. The causal relationship from electricity consumption to GDP growth was found by a group of studies, this relationship represents the growth hypothesis. The growth hypothesis signifies that energy conservation policies on energy consumption adversely affect GDP growth. In addition, a number of studies found a unidirectional causality from GDP growth to electricity consumption, this causal relationship represents the conservation hypothesis. The conservation hypothesis implies that energy conservation policies might result in little or no effect on GDP growth. On the other hand, few studies found no causal relationship between the two variables, this causal effect represents the neutrality hypothesis. The neutrality hypothesis indicates that energy conservation policies have no effect on GDP growth. From the literature presented in Table 2, there is lack of studies that explored the electricity consumption-GDP growth relationship in the GCC despite that this topic is well studied in the energy economics literature. Therefore, the purpose of this study is to examine electricity consumption and GDP growth relationship in the six Gulf Cooperation Council (GCC) countries for the period 1990–2012. The results will, consequently, indicate whether energy conservation policies are appropriate for these countries to reduce their high levels of electricity consumption. The autoregressive distributed lag (ARDL) and the Toda–Yamamoto–Dolado–Lütkepohl (TYDL) methodologies will be employed to investigate this relationship.

This is the first study for the GCC countries that examines this issue in the energy economics literature. Thus, this paper aims to fill this gap in literature. The findings of this study will help

Table 2
Summary of the literature on electricity consumption–GDP growth relationship.

Author	Period of study	Country/region	Methodology	Variables	Results	Hypothesis
Ho and Siu [3]	1966–2002	Hong Kong	Johansen cointegration and VECM Granger causality	Electricity consumption and GDP	The variables are cointegrated Electricity consumption → GDP	Growth hypothesis
Apergis and Payne [4]	1990–2006	88 countries based on income	Larsson's panel cointegration, VECM Granger causality	Electricity consumption, GDP, capital and labor	The variables are cointegrated Electricity consumption ↔ GDP in the high, upper middle and lower middle countries Electricity consumption → GDP for the low income countries	Feedback hypothesis for the high, upper middle and lower middle income countries Growth hypothesis for the low income countries
Tang [5]	1973–2003	Malaysia	autoregressive distributed lag (ARDL) model and Granger, ECM-based *F*-test for cointegration and MWALD causality tests	Electricity consumption and gross national product	No cointegration is found between the variables Electricity consumption ↔ GDP	Feedback hypothesis
Apergis and Payne [6]	1990–2007	South America	Larsson's panel cointegration, VECM Granger causality	GDP, renewable electricity consumption, non-renewable electricity consumption, real gross fixed capital formation, and the labor	The variables are cointegrated Electricity consumption ↔ GDP	Feedback hypothesis
Aslan [7]	1968–2008	Turkey	Autoregressive distributed lag (ARDL) model and VECM Gramger causality	Electricity consumption and GDP	The variables are cointegrated Electricity consumption ↔ GDP	Feedback hypothesis
Mozumder and Marathe [8]	1971–1999	Bangladesh	Johansen cointegration and VECM Granger causality	Electricity consumption and GDP	The variables are cointegrated Electricity GDP → electricity consumption	Conservation hypothesis
Jumbe [9]	1970–1999	Malawi	Engle and Granger [57] cointegration and Standard Granger causality and VECM Granger causality	Total GDP, Agriculture and non-agriculture GDP and electricity consumption	The variables are cointegrated but not for agriculture GDP GDP → electricity consumption For the standard Granger causality total GDP ↔ electricity consumption and	Feedback hypothesis
Narayan et al. [10]	1980–2006	93 Countries	Pedroni cointegration and VECM Granger causality	Electricity consumption and GDP	The variables are cointegrated Electricity consumption ↔ GDP in all countries expect for the Middle East GDP → electricity consumption in the Middle East	Feedback hypothesis in in all the countries expect for the Middle East Conservation hypothesis in the Middle East
Romano and Scandurra [11]	1980–2007	Italy	Pedroni cointegration and VECM Granger causality	Electricity consumption, employment and GDP	The variables are cointegrated Electricity consumption ↔ GDP	Feedback hypothesis
Kouakou [12]	1971–2008	Cote d'Ivoire	Autoregressive distributed lag (ARDL) model and VECM Granger causality	Electricity consumption, industrial output and GDP	The variables are cointegrated Electricity consumption ↔ GDP Electricity consumption → industrial output	Feedback hypothesis for the electricity consumption and GDP relationship Growth hypothesis for the relationship between electricity consumption and industrial output
Bildirici and Kayıkçı [13]	1990–2009	Former Soviet Republics organized by group	Pedroni cointegration, Autoregressive distributed lag (ARDL) model, fully modified OLS and VECM Granger causality	Electricity consumption and GDP	The variables are cointegrated for all groups Electricity consumption has a positive long run effect on GDP in the oil exporting group (Russian Federation, Azerbaijan and Kazakhstan) and the high income group (Armenia, Georgia and Ukraine) The long run relationship is negative for low income group (Kyrgyzstan, Moldova, Tajikistan and Uzbekistan) Electricity consumption → GDP	Growth hypothesis
Ciarreta and Zarraga [14]	1970–2007	12 European countries	Pedroni cointegration, fully modified OLS, GMM and VECM Granger causality	Electricity consumption, GDP and electricity prices	The variables are cointegrated Long run positive effect is found between electricity consumption and GDP Electricity consumption ↔ GDP	Feedback hypothesis

Table 2 (*continued*)

Author	Period of study	Country/region	Methodology	Variables	Results	Hypothesis
Wolde-Rufael [15]	1971–2001	17 African countries	Autoregressive distributed lag (ARDL) and Toda–Yamamoto approach to Granger causality	Electricity consumption and GDP	The long run relationship between the variables exists in 9 countries Electricity consumption → GDP in 3 countries GDP → electricity consumption in 6 countries Electricity consumption ↔ GDP in 3 countries	Growth hypothesis in Benin, Congo, DR and Tunisia Conservation hypothesis in Cameroon, Ghana, Nigeria, Senegal, Zambia and Zimbabwe Feedback hypothesis in Egypt, Gabon and Morocco
Squalli [16]	1980–2003	OPEC members	Autoregressive distributed lag (ARDL) and Toda–Yamamoto approach to Granger causality	Electricity consumption and GDP	The long run relationship between the variables exists in all countries Electricity consumption → GDP in 4 countries GDP → electricity consumption in 4 countries Electricity consumption ↔ GDP in 3 countries	Growth hypothesis in Indonesia, Nigeria, UAE and Venezuela Conservation hypothesis in Algeria, Iraq, Kuwait and Libya Feedback hypothesis in Iran, Qatar and Saudi Arabia
Shahbaz and Feridun [17]	1971–2008	Pakistan	Autoregressive distributed lag (ARDL) and Toda–Yamamoto approach and short run Wald-test Granger causality tests	Electricity consumption and GDP	The long run relationship between the variables exists GDP → electricity consumption	Conservation hypothesis
Yoo [18]	1970–2002	South Korea	Johansson cointegration and VECM Granger causality	Electricity consumption and GDP	The variables are cointegrated Electricity consumption ↔ GDP	Feedback hypothesis
Altinay and Karagol [19]	1950–2000	Turkey	The Dolado–Lütkepohl test and the standard Granger causality test	Electricity consumption and GDP	Electricity consumption → GDP	Growth hypothesis
Belaid and Abderrahmani [20]	1971–2010	Algeria	Cointegration test (Johansen and Gregory–Hansentests). VECM Granger causality	Electricity consumption, oil prices and GDP	The variables are cointegrated Electricity consumption ↔ GDP	Feedback hypothesis
Ouédraogo [21]	1968–2003	Burkina Faso	Autoregressive distributed lag (ARDL) model and VECM Granger causality	Electricity consumption, GDP and gross fixed capital formation	The variables are cointegrated Electricity consumption ↔ GDP	Feedback hypothesis
Shiu and Lam [22]	1971–2000	China	Johansen cointegration and VECM Granger causality	Electricity consumption and GDP	The variables are cointegrated Electricity consumption → GDP	Growth hypothesis
Yuan et al. [23]	1978–2004	China	Johansen cointegration and VECM Granger causality	Electricity consumption and GDP	The variables are cointegrated Electricity consumption → GDP	Growth hypothesis
Ghosh [24]	1950–1997	India	Johansen cointegration and VAR Granger causality	Electricity consumption and GDP	The variables are not cointegrated GDP → electricity consumption	Conservation hypothesis
Akinlo [25]	1980–2006	Nigeria	Johansen cointegration and VECM Granger causality	Electricity consumption and GDP	The variables are cointegrated Electricity consumption → GDP	Growth hypothesis
Yoo and Kwak [26]	1975–2006	7 South American countries	Johansen cointegration, Hsiao's version of the Granger causality tests and VECM Granger causality	Electricity consumption and GDP	The variables are cointegrated in Brazil, Columbia, Ecuador and Venezuela Electricity consumption → GDP in Argentina, Brazil, Chile, Columbia, and Ecuador Electricity consumption ↔ GDP in Venezuela Electricity consumption ≠ GDP in Peru	Growth hypothesis in Argentina, Brazil, Chile, Columbia, and Ecuador Feedback hypothesis in Venezuela Neutrality hypothesis in Peru
Odhiambo [27]	1971–2006	South Africa	Johansen cointegration and VECM Granger causality	Electricity consumption, GDP and employment	The variables are cointegrated Electricity consumption ↔ GDP	Feedback hypothesis
Ciarreta and Zarraga [28]	1971–2005	Spain	Toda and Yamamoto, Dolado and Lü tkepohl and VAR Granger causality	Electricity consumption and GDP	The variables are not cointegrated GDP → electricity consumption	Conservation hypothesis
Nazlioglu etl al. [29]	1967–2007	Turkey	Autoregressive distributed lag (ARDL) model and VECM Granger causality	Electricity consumption and GDP	The variables are cointegrated Electricity consumption ↔ GDP	Feedback hypothesis
Ahamad and Islam [30]	1971–2008	Bangladesh	Johansen cointegration and VECM Granger causality	Electricity consumption and GDP	The variables are cointegrated Electricity consumption → GDP	Growth hypothesis
Shahbaz et al. [31]	1971–2009	Portugal	Autoregressive distributed lag (ARDL) model using Unrestricted Error-Correction Model (UECM) and VECM Granger causality	Electricity consumption, GDP and employment	The variables are cointegrated Electricity consumption ↔ GDP	Feedback hypothesis
Abosedra et al. [32]	1995–2005	Lebanon	Bivariate Granger casualty	Electricity consumption, GDP and imports	Electricity consumption ↔ GDP	Growth hypothesis

Ozturk and Acaravci [33]	1971–2006	11 Middle East North African countries	Autoregressive distributed lag (ARDL) model and VECM Granger causality	Electricity consumption and GDP	The variables are cointegrated only in Egypt, Israel, Oman and Saudi Arabia	Feedback hypothesis In Oman Neutrality hypothesis for the rest of the 10 countries
Al-mulali et al. [34]	1980–2010	Latin American countries	Pedroni cointegration, dynamic OLS and VECM Granger causality	LGP, renewable and non-renewable electricity consumption, labor, gross fixed capital formation and trade openness	The variables are cointegrated Renewable and non-renewable electricity consumption have a positive long run relationship with GDP Electricity consumption $\leftrightarrow$ GDP	Feedback hypothesis
Narayan and Smyth [35]	1966–1999	Australia	Autoregressive distributed lag (ARDL) model using Unrestricted Error-Correction Model (UECM) and VECM Granger causality	Electricity consumption, GDP and employment	The variables are cointegrated GDP $\rightarrow$ electricity consumption	Conservation hypothesis
Aslan [36]	1980–2008	Turkey	Autoregressive distributed lag (ARDL) model, fully modified OLS, dynamic OLS and canonical co-integrating regression and VECM Granger causality	Electricity consumption, GDP and labor	A long run positive relationship between electricity consumption and GDP Electricity consumption $\leftrightarrow$ GDP	Feedback hypothesis
Abbas and Choudhury [37]	1972–2008	India and Pakistan	Johansen cointegration and VECM Granger causality	Agriculture GDP and agriculture electricity consumption GDP and electricity consumption	The variables are cointegrated GDP $\rightarrow$ electricity consumption in India GDP $\leftrightarrow$ electricity consumption in Pakistan Agriculture GDP $\leftrightarrow$ agriculture electricity consumption in India Agriculture GDP $\rightarrow$ agriculture electricity consumption in Pakistan	Feedback hypothesis for electricity consumption and GDP in Pakistan and agriculture GDP and agriculture electricity consumption in India Conservation hypothesis for the agriculture GDP and agriculture electricity consumption in Pakistan and electricity consumption and GDP in India
Acaravci and Ozturk [38]	1990–2006	Transition countries	Pedroni cointegration and VECM Granger causality	Electricity consumption and GDP	The variables are cointegrated Electricity consumption $\neq$ GDP	Neutrality hypothesis
Chandran et al. [39]	1971–2003	Malaysia	Autoregressive distributed lag (ARDL) model and VECM Granger causality	Electricity consumption and GDP	The variables are cointegrated Electricity consumption $\rightarrow$ GDP	Growth hypothesis
Narayan and Prasad [40]	1971–2002	OECD countries	Bootstrap simulation technique Granger causality	Electricity consumption and GDP	Electricity consumption $\rightarrow$ GDP in Australia, Iceland, Italy, the Slovak Republic, the Czech Republic, Korea, Portugal, and the UK Electricity consumption $\neq$ GDP	Growth hypothesis in Australia, Iceland, Italy, the Slovak Republic, the Czech Republic, Korea, Portugal, and the UK Neutrality hypothesis for the rest of the countries
Tang and Tan [41]	1970–2009	Malaysia	Autoregressive distributed lag (ARDL) model and VECM Granger causality	Electricity consumption, GDP, energy prices and technology innovation	The variables are cointegrated Electricity consumption $\leftrightarrow$ GDP	Feedback hypothesis
Cheng-Lang et al. [42]	1982–2008	Taiwan	Linear and non-linear causality	Industrial electricity consumption, residential electricity consumption and total electricity consumption and GDP	For the linear causality total electricity consumption, industrial electricity consumption $\leftrightarrow$ GDP Residential electricity consumption $\neq$ GDP For the non-linear causality total electricity consumption $\leftrightarrow$ GDP Residential electricity consumption $\rightarrow$ GDP	For the linear causality Feedback hypothesis for total electricity and industrial electricity consumption and GDP Neutrality hypothesis for the Residential electricity consumption and GDP For the non-linear causality feedback hypothesis for total electricity consumption and GDP Growth hypothesis for the Residential electricity consumption and GDP
Narayan and Smyth [43]	1974–2002	Middle East	Panel Fully modified OLS and VECM Granger causality	Electricity consumption, exports and GDP	Bi-directional long run relationship between electricity consumption and GDP	Feedback hypothesis
Lean and Smyth [44]	1970–2008	Malaysia	Autoregressive distributed lag (ARDL) model using Unrestricted Error-Correction Model (UECM) and TYDL Granger causality	Electricity consumption, exports, consumer price index and GDP	The variables are cointegrated GDP $\rightarrow$ electricity consumption	Conservation hypothesis

Table 2 (*continued*)

Author	Period of study	Country/region	Methodology	Variables	Results	Hypothesis
Tang et al. [45]	1974–2009	Portugal	Autoregressive distributed lag (ARDL) model and VECM Granger causality	Electricity consumption, GDP, price level, trade openness, financial development and foreign direct investment	The variables are cointegrated Electricity consumption ↔ GDP	Feedback hypothesis
Apergis and Payne [46]	1990–2007	Emerging market economies	Pedroni cointegration, fully modified OLS and VECM Granger causality	GDP, renewable electricity consumption, non-renewable electricity consumption, gross fixed capital formation, and labor	The variables are cointegrated Renewable and non-renewable electricity consumption has a long run positive relationship with GDP Renewable and non-renewable electricity consumption ↔ GDP	Feedback hypothesis
Apergis and Payne [47]	1990–2007	80 different countries	Pedroni cointegration, fully modified OLS and VECM Granger causality	GDP, renewable electricity consumption, non-renewable electricity consumption, gross fixed capital formation, and labor	The variables are cointegrated Renewable and non-renewable electricity consumption has a long run positive relationship with GDP Renewable and non-renewable electricity consumption ↔ GDP	Feedback hypothesis
Apergis and Payne [48]	1992–2007	Eurasia	Pedroni cointegration, fully modified OLS and VECM Granger causality	GDP, renewable electricity consumption, gross fixed capital formation, and labor	The variables are cointegrated Renewable electricity consumption has a long run positive relationship with GDP Renewable electricity consumption ↔ GDP	Feedback hypothesis
Yoo [49]	1971–2002	ASEAN countries	Johansen cointegration, standard Granger-causality test and Hsiao version of Granger causality	Electricity consumption and GDP	The variables are cointegrated Electricity consumption ↔ GDP in Malaysia and Singapore GDP → electricity consumption in Indonesia and Thailand	Feedback hypothesis for Malaysia and Singapore Conservation hypothesis for Indonesia and Thailand
Shahbaz and Lean [50]	1972–2009	Pakistan	Autoregressive distributed lag (ARDL) model and VECM Granger causality	Electricity consumption, capital, labor and GDP	The variables are cointegrated Electricity consumption ↔ GDP	Feedback hypothesis
Narayan and Singh [51]	1971–2002	Fiji Islands	Autoregressive distributed lag (ARDL) model, fully modified OLS, dynamic OLS, ordinary least square and VECM Granger causality	Electricity consumption, labor and GDP	A long run relationship between electricity consumption and GDP Electricity consumption → GDP	Growth hypothesis
Apergis and Payne [52]	1990–2007	Central America	Larsson panel cointegration test	GDP, renewable electricity consumption, non-renewable electricity consumption, gross fixed capital formation, and labor	The variables are cointegrated Renewable electricity consumption has a long run positive relationship with GDP Renewable electricity consumption ↔ GDP	Feedback hypothesis
Kula [53]	1980–2008	OECD	Pedroni cointegration, Dynamic OLS and VECM Granger causality	Renewable electricity consumption and GDP	The variables are cointegrated Long run positive relationship renewable electricity consumption and GDP GDP → renewable electricity consumption	Conservation hypothesis
Shengfeng et al. [54]	1953–2009	China	Johansen cointegration and VECM Granger causality	Electricity consumption and GDP	The variables are cointegrated Electricity consumption → GDP	Growth hypothesis
Apergis and Payne [55]	1980–2006	Central America	Pedroni cointegration, Fully modified OLS and VECM	GDP, renewable energy consumption, real gross fixed capital formation, and labor	The variables are cointegrated Renewable electricity consumption has a long run positive relationship with GDP Renewable electricity consumption ↔ GDP	Feedback hypothesis

policymakers to develop comprehensive energy policies and to see whether energy conservation policies are appropriate for these countries to reduce their high levels of electricity consumption without reducing their growth.

2. Data and methodology

2.1. Data

This study utilized annual data using the period 1980–2012 to investigate the 6 GCC countries, namely, Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates (UAE). To achieve the aims of this study, a GDP model was constructed whereby GDP growth was the dependent variable and fossil fuels electricity consumption, capital, labor force, and exports and imports of goods and services were the independent variables. These variables have been used by many scholars as main determinants for their GDP model in investigating the GDP growth-electricity consumption relationship (see Table 2). The time series model for GDP growth is presented below:

$$\mathrm{GDP}_t = f(\mathrm{EF}_t + \mathrm{L}_t + \mathrm{C}_t + \mathrm{EX}_t + \mathrm{IM}_t) \tag{1}$$

Each variable is presented in its natural log. Moreover, the error term is added to the GDP growth model. The model can be written as follows:

$$\ln\mathrm{GDP}_t = \beta_1 \ln\mathrm{EF}_t + \beta_2 \ln\mathrm{L}_t + \beta_3 \ln\mathrm{C}_t + \beta_4 \ln\mathrm{EX}_t + \beta_5 \ln\mathrm{IM}_t + \varepsilon_t \tag{2}$$

The β_1, β_2, β_3, β_4, and β_5 represent the slope coefficients, t is the time period (1980–2012), and ε is the error term. ln GDP is the log of the gross domestic product per capita measured in 2000 of constant US dollars, ln EF is the log of electricity consumption from fossil fuels per capita measured in thousands of kilowatt-hours, lnL is the log of economically active population measured in thousands of individuals as an indicator of labor, lnC is the gross fixed capital formation per capita measured in 2000 of constant US dollars, lnEX is the log of exports of goods and services per capita measured in 2000 of constant US dollars, and lnIM is the log of imports of goods and services. All the data were retrieved from the Euromonitor International database [56].

2.2. Methodology

There are various methods to test the cointegration relationship between variables. Cointegration techniques, such as the residual-based approach proposed by Engle and Granger [57], the maximum likelihood-based approach proposed by Johansen and Juselius [58], the fully modified OLS procedures of Phillips and Hansen [59], and the autoregressive distributed lag (ARDL) approach suggested by Pesaran et al. [60], are used vastly by scholars. Nonetheless, one of the main advantages of ARDL approach over the other cointegration approaches is that this method is applicable regardless of whether the underlying regressors are $I(0)$, $I(1)$, or fractionally integrated. This encouraged us to use this approach as an estimation technique of cointegration in this study. Testing the cointegration or long-run relationship among the economic variables is a crucial topic in econometric analysis. The existence of cointegration among the variables does not only show a long-run equilibrium relationship between the variables but also it can guarantee the consistent results obtained by employing the Ordinary Least Square (OLS) method for estimation.

The ARDL model of the long-run relationship between economic growth, export, import, electricity consumption from fossil fuels, capital, and labour is formulated as follows:

$$\begin{aligned}\Delta\ln\mathrm{GDP}_t = {} & \varnothing_0 + \sum_{k=1}^{n} \varnothing_{1k}\Delta\ln\mathrm{GDP}_{t-k} + \sum_{k=0}^{n} \varnothing_{2k}\Delta\ln\mathrm{EF}_{t-k} \\ & + \sum_{k=0}^{n} \varnothing_{3k}\Delta\ln\mathrm{C}_{t-k} + \sum_{k=0}^{n} \varnothing_{4k}\Delta\ln\mathrm{L}_{t-k} \\ & + \sum_{k=0}^{n} \varnothing_{5k}\Delta\ln\mathrm{EX}_{t-k} + \sum_{k=0}^{n} \varnothing_{6k}\Delta\ln\mathrm{IM}_{t-k} \\ & + Y_1\ln\mathrm{GDP}_{t-1} + Y_2\ln\mathrm{EF}_{t-1} + Y_3\ln\mathrm{C}_{t-1} \\ & + Y_4\ln\mathrm{L}_{t-1} + Y_5\ln\mathrm{EX}_{t-1} + Y_6\ln\mathrm{IM}_{t-1} + \varepsilon_t\end{aligned} \tag{3}$$

where $\varnothing_0$ is the drift components, $\varnothing_1$ to $\varnothing_6$ are the error correction dynamics, Y_1 toY_6 are the long-run relationship among variables, Δ is the first difference operator and ε_t is the white noise term.

In the ARDL bounds testing approach, the first step was to estimate the equation by OLS method. Subsequently, the F-test was conducted to test the existence of the long-run relationship among the variables. The F-statistics tests the null of no cointegration, $H_0: y_1 = y_2 = y_3 = y_4 = y_5 = y_6 = 0$, against the alternative of $H_1: y_1 \neq y_2 \neq y_3 \neq y_4 \neq y_5 \neq y_6 \neq 0$. The critical values of the F-statistics are available in Pesaran and Pesaran [61] and Pesaran et al. [60]. Narayan [62] argued that exiting critical values cannot be used for small sample sizes because they have been tabulated for sample sizes of 500 and 1000 observations. Narayan calculated critical values for sample sizes ranging from 30 to 80 observations. Given the small sample size in this study, the critical values of Narayan for the bounds F-test were employed.

There are two sets of critical values for a given significance level, one known as Lower Critical Bound (LCB) and the other is Upper Critical Bound (UCB). This provides a bound covering all possible classifications of the variables into $I(0)$ and $I(1)$. If the computed F-statistic is higher than the UCB, the null hypothesis of no cointegration is rejected. If it is below the LCB, the null hypothesis cannot be rejected. Additionally, if the computed F-statistic lies between the LCB and UCB, the result is inconclusive. At this stage of the estimation process, the ARDL approach estimates $(p+1)^k$ number of regression in order to obtain optimal lag length for each variable, where 'p' is the maximum number of lags to be used and "k" is the number of variables in the model. In order to choose the appropriate number of lags in the model $\overline{R}^2$, Schawrtz–Bayesian criteria (SBC), Hannan–Quinn Criterion (HQC) and Akaike's information criteria (AIC) can be employed. In this study AIC was implemented to select the maximum relevant lag length. It is a well-known criterion that is mostly used by scholars to select the lag orders of the variables. The long-run relationship among the variables can be estimated after the selection of the ARDL model by AIC criterion.

An Alternative way to test for the existence of the long run relationship among the variables of the model is to substitute the lagged level variables with an error correction term (ECT) and test for the significance of its coefficient. To obtain these coefficients, short-run error correction in Eq. (2) was estimated. In the next step, the lagged level term in each equation were replaced by the lagged value of constructed ECT and the model was estimated one more time with the same optimum number of lags selected by AIC. The ECT indicates the speed of the adjustment and shows how quickly the variables return to the long-run equilibrium. Moreover, the ECT should have a statistically significant coefficient with a negative sign for the cointegration relationship to exist. The general ECM of Eq. (2) is formulated as follows:

$$\begin{aligned}\Delta\ln\mathrm{GDP}_t = {} & \varnothing_0 + \sum_{k=1}^{n} \Delta\ln\mathrm{GDP}_{t-k} + \sum_{k=1}^{n} \varnothing_{2k}\Delta\mathrm{EF}_{t-k} \\ & + \sum_{k=1}^{n} \varnothing_{3k}\Delta\ln\mathrm{C}_{t-k} + \sum_{k=1}^{n} \varnothing_{4k}\Delta\ln\mathrm{L}_{t-k} + \sum_{k=1}^{n} \varnothing_{5k}\Delta\ln\mathrm{EX}_{t-k}\end{aligned}$$

$$+\sum_{k=1}^{n}\varnothing_{6k}\Delta\ln\mathrm{IM}_{t-k}+\theta\mathrm{ECM}_{t-1}+\varepsilon_t \quad (4)$$

After testing the long run relationship between the variables in the model, the next step was to estimate the long-run coefficients in Eq. (2). To ensure the goodness of fit of the model, the diagnostic and stability tests were conducted. Diagnostic tests include testing for serial correlation by Lagrange Multiplier (LM) statistics, functional form by Regression Equation Specification Error Test (RESET) proposed by Ramsey [63] using the square of the fitted values, normality based on a test of skewness and kurtosis of residual, and heteroscidasticity based on the regression of squared residuals on squared fitted. Furthermore, Pesaran et al. [60] suggested estimating the stability of long estimate through cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ). These tests were proposed by Brown et al. [64]. CUSUM and CUSUMSQ tests are general methods to test the stability and the structural break of the econometrics models. One of the advantages of the tests over the alternatives, such as Chow test, is that they do not require a prior determination of where the structural break takes place [65]. In order to check the stability and structural break of the long-run model, the CUSUM and CUSUMSQ tests were employed. Graphically, these two statistics are plotted within two straight lines bounded by the five percent significance level. If any point lies beyond this five percent level, the null hypothesis of stable parameters is rejected.

In order to test the causal relationship between economic growth, export, import, fossil fuels electricity consumption, capital, and labor, the Toda–Yamamoto–Dolado–Lütkepohl (TYDL) approach proposed by Toda and Yamamoto [66] and Dolado and Lütkepohl [67] was utilized. There are two main advantages for this method over the other causality approaches. First, this approach is applicable irrespective of whether the series are integrated of order zero ($I(0)$), one ($I(1)$) or two ($I(2)$). Second, this approach is applicable irrespective of the existence of the cointegration relationship between variables. The TYDL approach employs a modified Wald test (MWALD) with χ^2 distribution for restriction on the parameters of the VAR (k) where k is the appropriate lag length for the VAR system. The approach augments the current order (k) by the maximum order of integration ($d_{\max}$), thus VAR ($k+d_{\max}$) can be estimated.

In order to perform the TYDL approach, the first step was to test the integration order of the variables. To determine the maximum integration order of the variables, the Augmented Dickey–Fuller [68] ADF test was employed. Contrary to the Dickey-Fuller (DF) test, the ADF test constructs a parametric correction for higher-order correlation by assuming that the series follows an Autoregressive (AR) process of order ρ. It also includes ρ lagged difference terms of the dependent variable to the right-hand side of the regression. The ADF test is based on the following statistics:

$$t_\alpha=\hat{\alpha}/[se(\hat{\alpha})]$$

$\hat{\alpha}$ is the estimate, t_α is the t-ratio of α and $se(\hat{\alpha})$ is the coefficient standard error. There are two advantages to the ADF test. First, the asymptotic distribution of the t-ratio for α is independent of the number of lagged first differences included in the ADF regression. Second, it is asymptotically valid in the presence of a Moving Average (MA) component, provided that sufficient lagged difference terms are included in the regression.

The second step was to set up a VAR model in the levels of the data, regardless of the orders of the integration of the variables. The next step was to determine the optimum lag length for the variables based on the usual information criteria, such as AIC or SIC. The third step was to set up the VAR model with its new lag order of ($k+d_{\max}$). The fourth and final step was the implementation of non-Granger causality test by employing a standard Wald test.

To examine the causal direction between economic growth, export, import, fossil fuels electricity consumption, capital, and labor, the following augmented VAR ($k+d_{\max}$) model is estimated.

$$V_t=\alpha+\beta_1V_{t-1}+\beta_2V_{t-2}+\cdots+\beta_kV_{t-k}+\beta_{k+d_{\max}}V_{t-k+d_{\max}}+\varepsilon_t \quad (5)$$

$V_t=(\mathrm{GDP}_t,\mathrm{EX}_t,\mathrm{IM}_t,\mathrm{EF}_t,\mathrm{C}_t$ and $\mathrm{L}_t)\alpha$ is a (6×1) vector of constant, βs are (6×6) coefficient matrix, and ε_ts were assumed to be normally distributed and follow a white noise process. k is the optimal lags order for the VAR model, p is the sum of ($k+d_{\max}$), and $d_{\max}$ is the maximum order of integration for the variables in the model. The row i, column j element in β_k, equals zero for $k=1,2,\ldots,p$. The null hypothesis of the jth element of V_t does not Granger-cause the ith element of V_t while it is vice versa for the alternative hypothesis.

3. Empirical results

To make sure that the model of this study is applicable, the diagnostic and stability tests were utilized (the results are presented in Table 3). Based on the critical value of χ^2 for one degree of freedom, the null hypothesis of normality of residuals, null hypothesis of no first order serial correlation and null hypothesis of no heteroscedasticity were accepted in all the selected countries. Based on the critical values of χ^2 for two degrees of freedom, the null hypothesis of no misspecification of the functional form were accepted in all the estimated models. Furthermore, stability was supported in all countries because the plots of both CUSUM and CUSUMSQ fell inside the critical bounds of five percent significance level. The plots of CUSUM and CUSUMSQ tests are presented in Fig. 1.

Since the model is applicable and stable, the next step was to examine whether the long run relationship is present among the

Table 3
Diagnostic tests result.

Country	Serial Correlation $\chi^2(1)$ [p-value]	Functional Form $\chi^2(1)$ [p-value]	Normality $\chi^2(2)$ [p-value]	Heteroscedasticity $\chi^2(1)$ [p-value]	CUSUM/ CUSUMQ
Bahrain	0.05 [0.83]	0.11 [0.74]	1.51 [0.47]	0.71[0.4]	S/S
Kuwait	0.02 [0.89]	0.36 [0.55]	0.9 [0.64]	0.32 [0.56]	S/S
Oman	0.05 [0.83]	1.92 [0.17]	0.21 [0.90]	0.27[0.60]	S/S
Qatar	1.08 [0.3]	12.1 [0.001]	3.001 [0.22]	0.004 [0.95]	S/S
Saudi Arabia	0.002 [0.97]	3.33 [0.07]	0.91 [0.64]	0.1 [0.75]	S/S
United Arab Emirates	2.72 [0.1]	4.22 [0.04]	0.61 [0.74]	0.86 [0.35]	S/S

Note: The critical values of χ^2 for one degree of freedom at one percent, five percent and ten percent levels are 6.6349, 3.8415 and 2.7055, respectively. The critical values of χ^2 for two degrees of freedom at one percent, five percent and ten percent levels are 9.21, 5.991 and 4.605, respectively. S signifies the stable model.

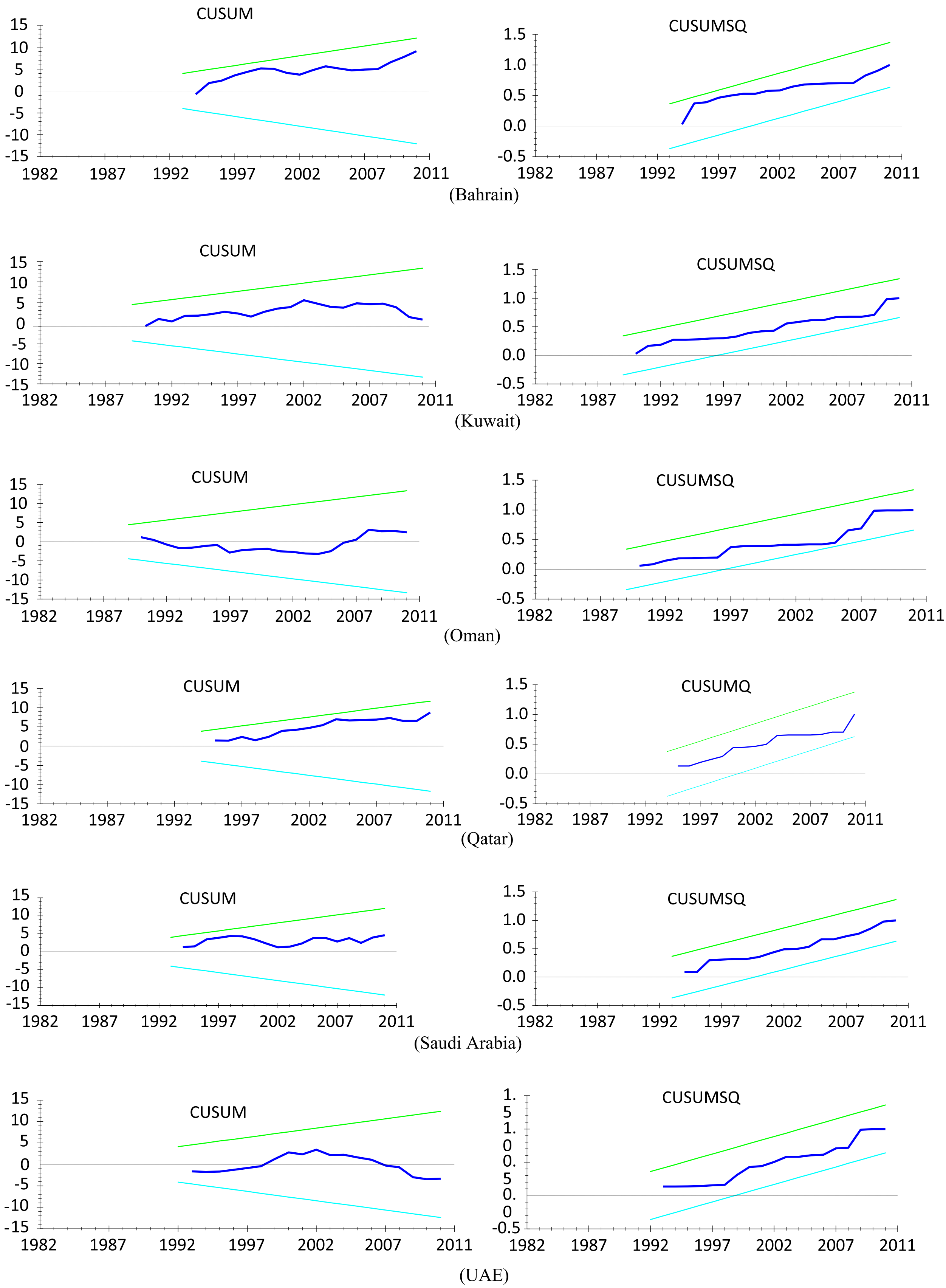

Fig. 1. Plots of CUSUM and CUSUMSQ tests for the parameter stability.

variables. Thus, the ARDL was utilized. The *F*-statistics was used to examine whether the variables are cointegrated. However, the *F*-statistics is sensitive to the optimal lag length for each first difference variables, therefore, a number of several tests were applied to insure that we choose the appropriate lag for each variable which is based on the minimum AIC. This procedure is

important because selecting the wrong lag length will violate the classical regression assumptions. Moreover, the model was estimated by applying the lag of error-correcting term (ECT_{t-1}) which is perceived as another tactic to determine cointegration. The significant and the negative coefficient from the ECT_{t-1} will designate the adjustment of the variables towards the equilibrium point, thus, to cointegration (Kremerset al. 1992). The ARDL cointegration results are presented in Table 4. Based on the *F*-statistics results, cointegration exists in Kuwait, Oman, Saudi Arabia, and the UAE. However, the error correction term also confirms cointegration in Bahrain, Oman, Qatar, and the UAE. The ARDL tests results in general reveal that the long run relationship between the variables do exist in all the of the GCC countries.

After the cointegration was confirmed among the countries, this study proceeded to estimate model 2 to get the long run coefficient so that the long run elasticities of the log GDP with the long run elasticities of the independent variables, namely, fossil fuels electricity consumption, capital, labour, and exports and imports of goods and services can be examined. The results in Table 5 reveal that exports of goods and services have a long run positive effect on GDP growth in all of the investigated countries. Moreover, imports of goods and services have a statistically significant positive long run effect in Bahrain, Kuwait, Oman, and Saudi Arabia as well as a significant long run negative effect in the UAE. However, the imports of goods and services have no significant effect on GDP growth in Qatar. The results for the capital show a significant long positive effect on GDP growth in Bahrain, Oman, Saudi Arabia, and the UAE while it has no significant long run effect on the GDP growth in Kuwait and Qatar. In addition, labour shows statistically significant long run negative relationship with GDP growth in Bahrain, Oman, and Saudi Arabia while it has no effect on GDP growth in rest of the countries.

Before we proceeded with the Granger causality, this study tested the stationarity of the variables which is presented in Table 6. The unit root test reveals that all the variables are stationary but at different levels, therefore, the Granger causality based on Toda–Yamamoto–Dolado–Lütkepohl (TYDL) was utilized. As mentioned previously, different from the other types of Granger causality, the TYDL Granger causality can work with variables that are integrated at levels, first difference and second deference.

Since the variables are stationary, the next step was to test the TYDL Granger causality which is revealed in Table 7. Results for Bahrain reveal a bi-directional causality between EF and GDP, EX and EF, IM and EF, L and IM, and between L and C. However, a unidirectional causality was found from GDP to EX, GDP to L, EX to L, and from EF to C. The Granger causality results for Kuwait show a one unidirectional causality from GDP to C, C to EX, C to IM, L to EF, and from L to C while no causality was confirmed between GDP and EF. The results for Oman show the existence of a bi-directional causality between EX and GDP, IM and GDP, C and GDP, and between EX and C. However, a one way causal relationship was concluded from EF to GDP, L to GDP, IM to EX, EF to EX, EF to IM, C to IM, L to IM, EF to C and L to C. The Granger causality for Qatar reveals a one way causality from EF to GDP, L to EX, and L to IM. For Saudi Arabia, a feedback causality was found between L and GDP, EX and IM, L and EX, and between EF and IM while a one way causal relationship was concluded from GDP to C, C to EX, IM to C, L to IM and from L to C. Moreover, no causality was found between EF and GDP in Saudi Arabia. The UAE results reveal a bi-directional causality between GDP and EX, EF and GDP, C and GDP, L and EX, IM and EF while unidirectional causality from IM to GDP, IM to EX, EX to EF, C to EX, C to IM, L to IM, EF to C, EF to L, and from L to C was found.

Table 4
Cointegration result.

Country	Optimal lags	*F*-statistics	ECM_{t-1}	Cointegration
Bahrain	[0,2,0,0,2,1]	1.68	−0.5(−2.39)**	Yes
Kuwait	[0,0,0,0,1,0]	4.55*	−0.22(−1.39)	Yes
Oman	[0,0,0,1,0,0]	3.89*	−0.42(−3.65)***	Yes
Qatar	[1,1,1,2,1,0]	2.76	−0.39(−2.28)**	Yes
Saudi Arabia	[0,1,0,0,2,2]	4.98**	−0.1(−1.16)	Yes
United Arab Emirates	[1,2,0,0,0,1]	4.001*	−0.79(−13.21)***	Yes

Notes: Numbers in the brackets are the optimum lags using AIC for lnGDP, lnEF, lnL, lnC, lnEX and lnIM respectively. The upper bound critical value of the *F*-test for cointegration is 3.86 at the 10% level of significance ([62], p. 1988). The values in parentheses are the *t*-ratios.

* Significance at 10% level.
** Significance at 5% level.
*** Significance at 1% level.

4. Conclusion and policy implications

The aim of this study was to explore the electricity consumption-GDP growth nexus relationship in the 6 GCC countries. To achieve the aims of this study, a GDP model was established taking the period 1980–2012. The autoregressive

Table 6
Unit root test results.

Country	lnGDP	lnEX	lnIM	lnEF	lnC	lnL	d_{max}
Bahrain	I(0)	I(1)	I(1)	I(0)	I(1)	I(0)	I(1)
Kuwait	I(1)	I(1)	I(1)	I(1)	I(1)	I(0)	I(1)
Oman	I(0)	I(0)	I(1)	I(0)	I(0)	I(1)	I(1)
Qatar	I(0)	I(0)	I(0)	I(0)	I(0)	I(1)	I(1)
Saudi Arabia	I(1)	I(1)	I(1)	I(1)	I(0)	I(0)	I(1)
United Arab Emirates	I(1)	I(1)	I(1)	I(0)	I(0)	I(0)	I(1)

Note: The optimal lag length is selected automatically by using the AIC.

Table 5
Long-run coefficient estimates.

Country	Constant	LnEX	IM	Ln EF	Ln C	LnL
Bahrain	−19.39(−2.36)	0.49(5.76)***	0.36(4.15)**	1.24(8.88)***	0.14(4.59)***	−1.36(−5.46)***
Kuwait	−2.87(−2.2)	0.5(18.99)***	0.3(6.59)***	0.18(3.17)**	0.05(1.31)	0.09(1.15)
Oman	−3.16(0.08)	0.44(15.55)***	0.2(2.64)**	0.4(8.31)***	0.08(1.85)*	−0.42(−3.99)***
Qatar	0.52(−7.09)	0.41(2.22)**	−0.03(−0.08)	0.06(0.18)	0.32(1.53)	0.38(1.31)
Saudi Arabia	−1.74(−2.97)	0.35(7.54)***	0.18(2.59)**	0.4(5.44)***	0.24(2.66)**	−0.51(−3.71)***
United Arab Emirates	−2.25(−9.47)	0.75(13.77)***	−0.34(−4.26)***	0.34(6.45)***	0.16(2.72)**	−0.02(−0.25)

Note: Numbers in parentheses are the *t*-ratios.

* Significance at 10% level.
** Significance at 5% level.
*** Significance at 1% level.

Table 7
TYDL Granger causality test results.

	lnGDP	lnEX	lnIM	lnEF	lnC	lnL
Bahrain						
lnGDP	–	3.2235 [0.1995]	0.955 [0.6203]	9.8193 [0.0074]***	0.8244 [0.6622]	1.0657 [0.5869]
lnEX	9.1319 [0.01]]***	–	0.016 [0.9918]	4.9021 [0.0862]*	1.7313 [0.4208]	1.4159 [0.4927]
lnIM	0.4932 [0.7815]	0.3894 [0.8231]	–	5.0647 [0.0795]*	0.3253 [0.8499]	17.662 [0.0001]***
lnEF	9.325 [0.0094]***	4.8196 [0.089]*	5.2737 [0.0716]*	–	0.381 [0.8265]	47.3789 [0.000]***
lnC	1.678 [0.4321]	2.5367 [0.2813]	1.076 [0.5837]	11.9642 [0.003]***	–	10.095 [0.006]***
lnL	31.035 [0.000]***	20.9347 [0.00]***	17.831 [0.0001]***	1.6856 [0.4305]	6.4875 [0.039]***	–
Kuwait						
lnGDP	–	2.3839 [0.3036]	3.738 [0.1543]	3.8842 [0.1434]	0.2383 [0.8876]	2.6712 [0.263]
lnEX	1.4626 [0.4813]	–	3.9354 [0.1398]	4.1487 [0.1256]	0.0939 [0.9541]	1.8271 [0.4011]
lnIM	0.0705 [0.9653]	0.4323 [0.8056]	–	0.4329 [0.8054]	2.1827 [0.3358]	2.29 [0.3182]
lnEF	0.9951 [0.608]	2.0959 [0.3507]	3.1198 [0.2102]	–	0.4833 [0.7853]	9.8314 [0.0073]***
lnC	5.9874 [0.05]**	6.5073 [0.0386]**	9.4024 [0.0091]***	2.4103 [0.2996]	–	6.8207 [0.033]***
lnL	3.141 [0.2079]	2.2209 [0.3294]	0.7232 [0.6966]	0.1792 [0.9143]	1.2713 [0.5296]	–
Oman						
lnGDP	–	6.6234 [0.0849]*	9.4166 [0.0242]***	228.3217 [0.000]***	18.533 [0.0003]***	11.0936 [0.011]***
lnEX	22.7958 [0.000]***	–	19.88 [0.0002]***	170.095 [0.000]***	47.76 [0.000]***	5.6621 [0.1293]
lnIM	3.3435 [0.3416]	4.6604 [0.1984]	–	104.088 [0.000]***	8.8254 [0.0317]**	19.2747 [0.0002]***
lnEF	6.0929 [0.1072]	4.1978 [0.2409]	4.583 [0.205]	–	4.6939 [0.1956]	5.4362 [0.1425]
lnC	9.1429 [0.0274]***	12.967 [0.005]***	0.8794 [0.8304]	82.1757 [0.000]***	–	10.3572 [0.0158]***
lnL	0.7321 [0.8656]	1.1146 [0.7735]	1.8664 [0.6006]	64.7781 [0.000]***	5.2582 [0.1538]	–
Qatar						
lnGDP	–	5.9612 [0.1135]	3.0758 [0.3801]	6.8203 [0.0779]*	2.2309 [0.5259]	5.1285 [0.1626]
lnEX	3.4074 [0.3330]	–	2.6757 [0.4444]	6.0154 [0.1109]	2.7179 [0.4372]	4.1857 [0.2421]
lnIM	2.7594 [0.4302]	1.9536 [0.5821]	–	1.961 [0.5805]	0.6812 [0.8776]	8.2818 [0.0405]**
lnEF	3.4403 [0.3286]	4.3573 [0.2254]	4.1792 [0.2428]	–	5.3442 [0.1483]	5.0255 [0.1699]
lnC	1.5495 [0.6709]	1.7845 [0.6183]	2.991 [0.393]	4.2914 [0.2317]	–	7.8785 [0.0486]**
lnL	3.283 [0.35]	6.3956 [0.0939]*	1.1001 [0.7771]	0.1142 [0.9901]	3.5883 [0.3095]	–
Saudi Arabia						
lnGDP	–	0.686 [0.4075]	1.848 [0.1740]	0.7859 [0.3753]	0.0586 [0.8088]	4.8011 [0.0284]**
lnEX	1.4885 [0.2224]	–	4.9699 [0.0258]**	0.2786 [0.5976]	0.7684 [0.3807]	4.1999 [0.0404]**
lnIM	5.0817 [0.0242]**	6.8119 [0.0091]***	–	3.1154 [0.0776]*	0.9156 [0.3386]	0.6046 [0.4368]
lnEF	1.5049 [0.2199]	2.0179 [0.1555]	2.9258 [0.0872]*	–	2.2449 [0.1341]	1.3506 [0.2452]
lnC	3.4636 [0.0627]**	3.7108 [0.0541]**	3.4333[0.0639]*	0.2401 [0.6241]	–	3.9666 [0.0464]**
lnL	4.6224 [0.0316]**	4.9278 [0.0264]**	6.1469[0.0132]**	3.4981 [0.0614]*	3.5262 [0.0604]*	–
UAE						
lnGDP	–	19.1032 [0.0003]***	3.1067 [0.3755]	6.2737 [0.0990]*	6.7555 [0.0801]*	12.8591 [0.005]***
lnEX	8.386 [0.0387]**	–	2.6463 [0.4494]	4.8374 [0.1841]	5.5087 [0.1381]	16.3536 [0.001]***
lnIM	6.5156 [0.0891]*	17.3268 [0.0006]***	–	7.52 [0.057]**	10.08 [0.0179]**	14.4028[0.0024]***
lnEF	6.6566 [0.0837]*	16.8294 [0.0008]***	46.6149 [0.00]***	–	4.6568 [0.1987]	3.746 [0.2902]
lnC	18.225 [0.0004]***	25.9191 [0.0000]***	18.42 [0.0004]***	19.632 [0.0002]***	–	13.819 [0.0032]***
lnL	9.9221 [0.0192]***	21.2397 [0.0001]***	2.3865 [0.4961]	9.7146 [0.0212]**	0.6808 [0.8777]	–

Note: The numbers in brackets indicate *p*-values. Significance implies that the column variable Granger causes the row variable.

* Represents 10% level of significance.
** Represents 5% level of significance.
*** Represents 1% level of significance.

distributed lag (ARDL) approach was utilized to examine the long run relationship and the Toda–Yamamoto–Dolado–Lütkepohl (TYDL) Granger causality was used to examine the short run relationship between the variables. The most important findings in the ARDL test results is that the GDP growth, fossil fuels electricity consumption, labor, capital, and exports and imports of goods and services are cointegrated. Moreover, it was found that electricity consumption has a long run positive relationship with GDP growth in the investigated countries.

The TYDL results show different GDP growth-electricity consumption causality relationships among the countries. Bidirectional causality was found between fossil fuels electricity consumption and GDP growth which indicates the existence of the feedback hypothesis in Bahrain and the UAE. However, for Oman and Qatar, a unidirectional causality was found from fossil fuels electricity consumption to GDP growth which represents the presence of the growth hypothesis. Nonetheless, no causality between the variables was found in Kuwait and Saudi Arabia, this represents the neutrality hypothesis. From the results above, it is clear that energy conservation is not an ideal policy for Bahrain, UAE, Oman, and Qatar because it will have a negative effect on the GDP growth. However, utilizing this policy is essential for Kuwait and Saudi Arabia since it will not harm their GDP growth.

There are several important policies that can be implemented by these countries to reduce their high consumption of electricity, for instance increasing their investment on energy saving, energy efficiency projects, and making projects and investment that increase the role of renewable energy sources.

Since electricity is generated in the GCC countries mostly by fossil-fueled (oil or gas) power plants, the levels of CO_2 emissions are rising rapidly in the GCC countries, especially in Saudi Arabia and Qatar. This creates the challenge of finding new renewable or cleaner sources of power generation to reduce the negative effects of greenhouse gas emissions. Since the governmental tax and pricing policies with regard to electrical consumption and the related CO_2 emissions vary significantly from one GCC country to the other, each country should apply the different programs according to their conditions to reduce increases in future

electricity demand and carbon emissions. Moreover, the increase in environmental education opportunities for youth and the participation in environmental programs can help to increase the environmental awareness in these countries.

References

[1] The World Bank. World Development Indicators. Washington, DC; 2014 [Online] Available from: 〈http://data.worldbank.org/data-catalog/world-development-indicators〉.
[2] Energy Information Administration (EIA). International Energy Statistics. Washington, DC; Available from: 〈http://www.eia.gov/countries/data.cfm〉.
[3] Ho CY, Siu KW. A dynamic equilibrium of electricity consumption and GDP in Hong Kong: an empirical investigation. Energy Policy 2007;35:2507–13.
[4] Apergis N, Payne JE. A dynamic panel study of economic development and the electricity consumption-growth nexus. Energy Econ 2011;33:770–81.
[5] Tang CF. A re-examination of the relationship between electricity consumption and economic growth in Malaysia. Energy Policy 2008;36:3077–85.
[6] Apergis N, Payne JE. Another look at the electricity consumption-growth nexus in South America. Energy Sources Part B 2013;8:171–8.
[7] Aslan a. Causality between electricity consumption and economic growth in Turkey: an ARDL bounds testing approach. Energy Sources Part B 2014;9:25–31.
[8] Mozumder P, Marathe A. Causality relationship between electricity consumption and GDP in Bangladesh. Energy Policy 2007;35:395–402.
[9] Jumbe CBL. Cointegration and causality between electricity consumption and GDP: empirical evidence from Malawi. Energy Econ 2004;26:61–8.
[10] Narayan PK, Narayan S, Popp S. Does electricity consumption panel Granger cause GDP? A new global evidence Appl Energy 2010;87:3294–8.
[11] Romano AA, Scandurra G. Dynamics of economic growth and electricity consumption at regional level: the Italian case. Energy Syst 2011;2:143–50.
[12] Kouakou AK. Economic growth and electricity consumption in Cote d'Ivoire: evidence from time series analysis. Energy Policy 2011;39:3638–44.
[13] Bildirici M, Kayıkçı F. Economic growth and electricity consumption in former Soviet Republics. Energy Econ 2012;34:747–53.
[14] Ciarreta A, Zarraga A. Economic growth-electricity consumption causality in 12 European countries: a dynamic panel data approach. Energy Policy 2010;38:3790–6.
[15] Wolde-Rufael Y. Electricity consumption and economic growth: a time series experience for 17 African countries. Energy Policy 2006;34:1106–14.
[16] Squalli J. Electricity consumption and economic growth: bounds and causality analyses of OPEC members. Energy Econ 2007;29:1192–205.
[17] Shahbaz M, Feridun M. Electricity consumption and economic growth empirical evidence from Pakistan. Qual Quant 2012;46:1583–99.
[18] Yoo SH. Electricity consumption and economic growth: evidence from Korea. Energy Policy 2005;33:1627–32.
[19] Altinay G, Karagol E. Electricity consumption and economic growth: evidence from Turkey. Energy Econ 2005;27:849–56.
[20] Belaid F, Abderrahmani F. Electricity consumption and economic growth in Algeria: a multivariate causality analysis in the presence of structural change. Energy Policy 2013;55:286–95.
[21] Ouédraogo IM. Electricity consumption and economic growth in Burkina Faso: a cointegration analysis. Energy Econ 2010;32:524–31.
[22] Shiu A, Lam PL. Electricity consumption and economic growth in China. Energy Policy 2004;32:47–54.
[23] Yuan J, Zhao C, Yu S, Hu Z. Electricity consumption and economic growth in China: cointegration and co-feature analysis. Energy Econ 2007;29:1179–91.
[24] Ghosh S. Electricity consumption and economic growth in India. Energy Policy 2002;30:125–9.
[25] Akinlo AE. Electricity consumption and economic growth in Nigeria: evidence from cointegration and co-feature analysis. J Policy Model 2009;31:681–93.
[26] Yoo SH, Kwak SY. Electricity consumption and economic growth in seven South American countries. Energy Policy 2010;38:181–8.
[27] Odhiambo NM. Electricity consumption and economic growth in South Africa: a trivariate causality test. Energy Econ 2009;31:635–40.
[28] Ciarreta A, Zarraga A. Electricity consumption and economic growth in Spain. Appl Econ Lett 2010;17:1417–21.
[29] Nazlioglu S, Kayhan S, Adiguzel U. Electricity consumption and economic growth in Turkey: cointegration, linear and nonlinear Granger causality. Energy Sources Part B 2014;9:315–24.
[30] Ahamad MG, Islam AK MN. Electricity consumption and economic growth nexus in Bangladesh: revisited evidences. Energy Policy 2011;39:6145–50.
[31] Shahbaz M, Tang CF, Shabbir MS. Electricity consumption and economic growth nexus in Portugal using cointegration and causality approaches. Energy Policy 2011;39:3529–36.
[32] Abosedra S, Dah A, Ghosh S. Electricity consumption and economic growth, the case of Lebanon. Appl Energy 2009;86:429–32.
[33] Ozturk I, Acaravci A. Electricity consumption and real GDP causality nexus: evidence from ARDL bounds testing approach for 11 MENA countries. Appl Energy 2011;88:2885–92.
[34] Al-mulali U, Fereidouni HG, Lee JYM. Electricity consumption from renewable and non-renewable sources and economic growth: evidence from Latin American countries. Renewable Sustainable Energy Rev 2014;30:290–8.
[35] Narayan PK, Smyth R. Electricity consumption, employment and real income in Australia evidence from multivariate Granger causality tests. Energy Policy 2005;33:1109–16.
[36] Aslan A. Electricity consumption, labor force and GDP in Turkey: evidence from multivariate Granger causality. Energy Sources Part B 2014;9:174–82.
[37] Abbas F, Choudhury N. Electricity consumption-economic growth Nexus: an aggregated and disaggregated causality analysis in India and Pakistan. J Policy Model 2013;35:538–53.
[38] Acaravci A, Ozturk I. Electricity consumption-growth nexus: evidence from panel data for transition countries. Energy Econ 2010;32:604–8.
[39] Chandran VGR, Sharma S, Madhavan K. Electricity consumption–growth nexus: the case of Malaysia. Energy Policy 2010;38:606–12.
[40] Narayan PK, Prasad A. Electricity consumption-real GDP causality nexus: evidence from a bootstrapped causality test for 30 OECD countries. Energy Policy 2006;36:910–8.
[41] Tang CF, Tan EC. Exploring the nexus of electricity consumption, economic growth, energy prices and technology innovation in Malaysia. Appl Energy 2013;104:297–305.
[42] Cheng-Lang Y, Lin HP, Chang CH. Linear and nonlinear causality between sectoral electricity consumption and economic growth: evidence from Taiwan. Energy Policy 2010;38:6570–3.
[43] Narayan PK, Smyth R. Multivariate Granger causality between electricity consumption, exports and GDP: evidence from a panel of Middle Eastern countries. Energy Policy 2009;37:229–36.
[44] Lean HH, Smyth R. Multivariate Granger causality between electricity generation, exports, prices and GDP in Malaysia. Energy 2010;35:3640–8.
[45] Tang CF, Shahbaz M, Arouri M. Re-investigating the electricity consumption and economic growth nexus in Portugal. Energy Policy 2013;62:1515–24.
[46] Apergis N, Payne JE. Renewable and non-renewable electricity consumption-growth nexus: evidence from emerging market economies. Appl Energy 2011;88:5226–30.
[47] Apergis N, Payne JE. Renewable and non-renewable energy consumption-growth nexus: evidence from a panel error correction model. Energy Econ 2012;34:733–8.
[48] Apergis N, Payne JE. Renewable energy consumption and growth in Eurasia. Energy Econ 2010;32:1392–7.
[49] Yoo SH. The causal relationship between electricity consumption and economic growth in the ASEAN countries. Energy Policy 2006;34:3573–82.
[50] Shahbaz M, Lean HH. The dynamics of electricity consumption and economic growth: a revisit study of their causality in Pakistan. Energy 2012;39:146–53.
[51] Narayan PK, Singh B. The electricity consumption and GDP nexus for the Fiji Islands. Energy Econ 2007;29:1141–50.
[52] Apergis N, Payne JE. The electricity consumption-growth nexus: renewable versus non-renewable electricity in Central America. Energy Sources Part B 2012;7:423–31.
[53] Kula F. The long-run relationship between renewable electricity consumption and GDP: evidence from panel data. Energy Sources Part B 2014;9:156–60.
[54] Shengfeng X, sheng XM, tianxing Z, Xuelli Z. The relationship between electricity consumption and economic growth in China. Physics Procedia 2012;24:56–62.
[55] Apergis N, Payne JE. The renewable energy consumption–growth nexus in Central America. Appl Energy 2011;88:343–7.
[56] Euromonitor International (EUROSTAT), 2014 [Online] [Accessed on 13th February 2013] Available from: 〈http://www.euromonitor.com〉.
[57] Engle RF, Granger CWJ. Co-integration and error correction: representation, estimation, and testing. Econometrica 1987;55:251–76.
[58] Johansen S, Juselius K. Maximum likelihood estimation and inferences on cointegration-with applications to the demand for money. Oxford Bull Econ Stat 1990;52:169–210.
[59] Phillips PCB, Hansen BE. Statistical inference in instrumental variables regression with I (1) processes. Rev Econ Stud 1990;57:99–125.
[60] Pesaran MH, Shin Y, Smith RJ. Bounds testing approaches to the analysis of level relationships. J Appl Econ 2001;16:289–326.
[61] Pesaran MH, Pesaran B. Working with microfit 4.0: interactive econometric analysis. Oxford: Oxford University Press; 1997.
[62] Narayan PK. The saving and investment nexus for China: evidence from cointegration tests. Appl Econ 2005;37:1979–90.
[63] Ramsey JB. Tests for specification errors in classical linear least-squares regression analysis. J R Stat Soc B 1969;31:350–71.
[64] Baltigi BH. Econometrics. 5th ed.. UK: Springer; 2000.
[65] Brown R, Durbin J, Evans J. Techniques for testing the constancy of regression relationships over time. J R Stat Soc B 1975;37:149–72.
[66] Toda HY, Yamamoto T. Statistical inference in vector autoregressions with possibly integrated processes. J Econ 1995;66:225–50.
[67] Dolado JJ, Lütkepohl H. Making Wald tests work for cointegrated VAR systems. Econ Rev 1996;15:369–86.
[68] Dickey DA, Fuller WA. Distribution of the estimators for autoregressive time series with a unit root. J Am Stat Assoc 1979;74:427–31.